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Helminth Parasites of the Alimentary Tract of the Harbor Porpoise, *Phocoena phocoena* (L.), from Newfoundland and Labrador

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ABSTRACT: Stomachs ($N = 80$) and intestines ($N = 29$) of the harbor porpoise, *Phocoena phocoena,* caught as a by-catch in fishing gear off southeastern Newfoundland and adjacent areas during summer and fall 1987–1991 were examined for helminth parasites. Three species of ascaridoid nematode (*Anisakis simplex, Contracaecum osculatum,* and *Phocascaris* sp.), 3 cestodes (*Diphyllobothrium* sp. plerocercoids, *D. stemmacephalum,* and *Tetrabothrius* sp.), 1 acanthocephalan (*Bolbosoma* sp.), and 1 digenean (*Campula oblongata*) were found. All age groups except calves (<1 yr old) were infected with helminths, but there were no significant differences in prevalence or abundance of parasite species among the remaining host age groups or between sexes. Porpoises acquired many larvae of the phocid parasites *C. osculatum* and *Phocascaris* sp., apparently from feeding on capelin, *Mallotus villosus,* but these parasites did not develop to maturity. Small numbers (1–38) of adult *A. simplex* were found in the forestomach of 5% of the porpoises; other helminths were rare. Data on numbers of adult *A. simplex* in other local species of cetaceans are limited, but the numbers of adult *A. simplex* found in *P. phocoena* are consistently lower, suggesting that the harbor porpoise occupying inshore waters during the summer months is not a major source of larval *A. simplex* for local fish stocks.

KEY WORDS: harbor porpoise, helminths, *Anisakis simplex, Contracaecum osculatum, Phocascaris* sp., *Campula oblonga, Tetrabothrius* sp., *Diphyllobothrium stemmacephalum, Bolbosoma* sp.

The harbor porpoise, *Phocoena phocoena* (L.), is one of the most abundant small cetaceans in temperate waters of the Northern Hemisphere. There are numerous records of gastrointestinal helminths in this marine mammal from the Atlantic (Scott and Fisher, 1958a; Vik, 1963; van Thiel, 1966; Young, 1972; F. R. Smith and Threlfall, 1973; Margolis and Arai, 1989 and references therein; J. W. Smith, 1989; Baker and Martin, 1992), but most parasitological studies are based on examination of small numbers (<10) of animals. In this study, a large number of porpoise stomachs ($N = 80$) and intestines ($N = 29$), collected during a program to estimate the total by-catch of these marine mammals in fishing gear, were subjected to parasitological examination.

The main objectives of this study were to determine the numbers of adult *Anisakis simplex* (Nematoda: Ascaridoidea) in harbor porpoises and thereby obtain information on the role of these cetaceans in the transmission of this parasite to local fish stocks. The third-stage larvae (L3's) of *A. simplex* B (=*A. simplex* sensu stricto; for taxonomy, see Nascetti et al., 1986) are common in the flesh of marine fishes off Atlantic Canada (McClelland et al., 1985, 1990; McGladdery, 1986; Brattey and Bishop, 1992) and are potential human pathogens when consumed in raw, marinated, or lightly cooked seafood (Oshima, 1987; McKerrow et al., 1988). Cetaceans normally serve as definitive hosts for species of *Anisakis* (van Thiel, 1966; Davey, 1971; J. W. Smith and Wootten, 1978; Margolis and Arai, 1989), but it is not clear which of the many species of cetaceans occurring off eastern Canada are important definitive hosts for this nematode. Information is presented on the levels of infection in the harbor porpoise of *A. simplex* and other helminths, together with data on the stages of maturity of the parasites and their distribution along the alimentary tract.

Materials and Methods

Harbor porpoises were caught by fishermen as an incidental by-catch in fishing gear set at 40–90 m deep in St. Mary's Bay and Placentia Bay and around the Avalon Peninsula and adjacent areas (Table 1, Fig. 1) during June–August 1990–1991. Two porpoises were obtained from these areas during the summer of 1987. Whole porpoises were placed on ice immediately upon arrival at the wharf and transported within 2 hr to the laboratory, where they were frozen (−30°C) whole for storage. One additional animal caught in October 1991 off southern Labrador during a Department of Fisheries and Oceans survey was dissected upon capture and the gastrointestinal tract frozen immediately. Porpoises were thawed in the laboratory and the sex, length (nearest centimeter), and weight (nearest kilogram) of each animal were recorded. The lower jaw was also removed and a tooth extracted from the middle of the lower mandible; the age of all except 5 animals was determined by examining growth layer groups in stained sections of the tooth using methods described by Rich-

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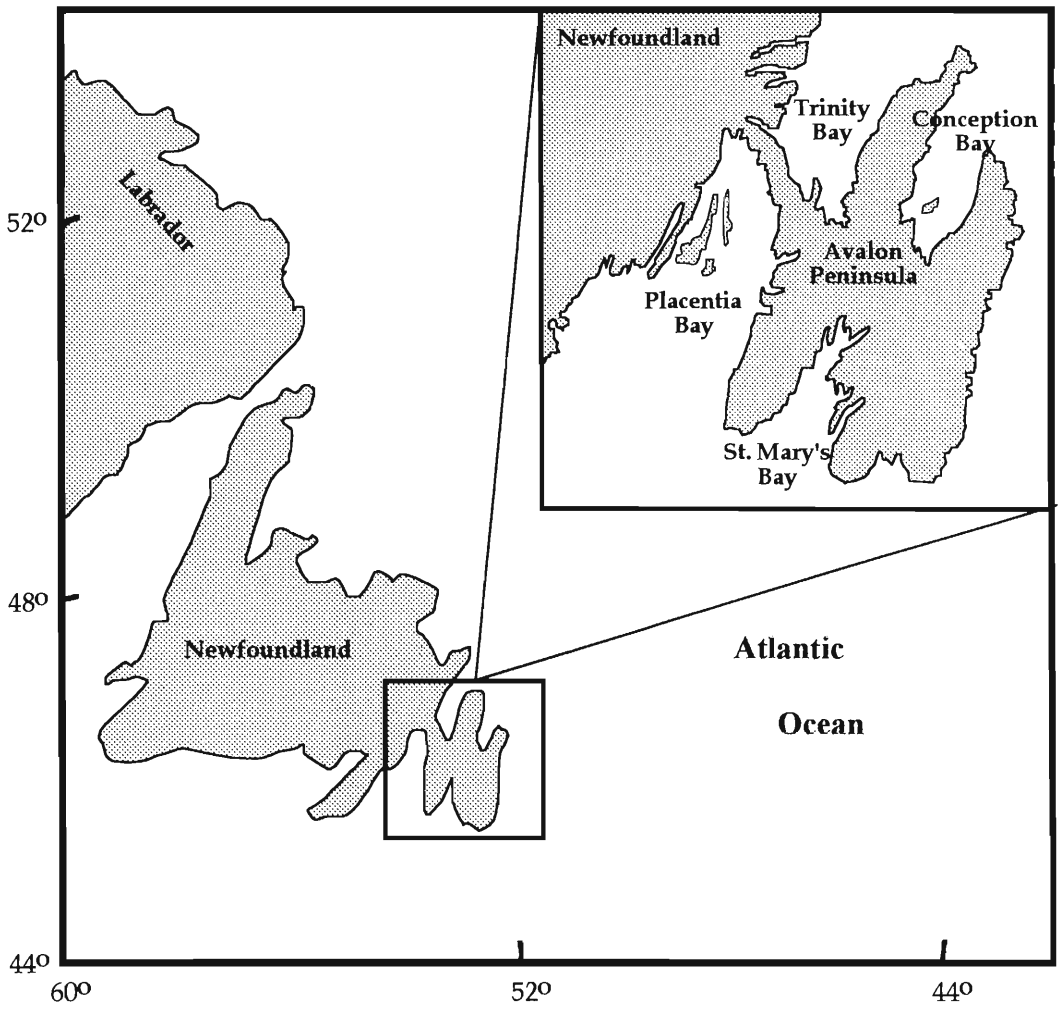

Figure 1. Sampling area for the harbor porpoise, *Phocoena phocoena*.

ardson (1992). Thirty-three female and 49 male porpoises of a wide range of ages were examined (maximum 9 yr old for females, 13 for males); they were classified into 4 age groups for analysis: calves (<1 yr old), immatures (1–3), young adults (4–6), and old adults (≥7 yr) (Table 1). Stomachs and intestines were removed, usually while the animal was still partially frozen, and parasites were extracted from food items and mucosa. Digestive tracts were in excellent condition upon examination. Gut contents together with scrapings of mucosa were washed through 4 fine-meshed sieves (850, 500, 355, and 53 μm), and the washings were collected and searched with a binocular dissecting microscope (×40 magnification). Major prey items were identified. The intestine was divided into 10 sections of approximately equal length, and separate counts of helminths were kept for each of the 3 stomach compartments (G. J. D. Smith, 1972) and the 10 intestinal sections. Ascaridoid nematodes were fixed in glacial acetic acid, preserved in glycerin–alcohol, and cleared in glycerin or lactic acid; they were identified and categorized as L3's or L4's, adult males, immature adult females (with no eggs in the uterus), or mature adult females (with fully developed eggs in the uterus). Other helminths (cestodes, digeneans, and acanthocephalans) were fixed in alcohol–formalin–acetic acid, stained in borax carmine or Ehrlich's hematoxylin, and mounted in Canada balsam. Parasite occurrence was expressed in terms of prevalence (% infected) and abundance (mean number of parasites per host including uninfected hosts ± standard error) following Margolis et al. (1982). Representative specimens have been deposited at the Atlantic Reference Centre, Huntsman Marine Laboratory, St. Andrews, New Brunswick, Canada E0G 2X0.

Results

A total of 8 helminth taxa, comprising 3 ascaridoid nematodes (*Anisakis simplex* Rudolphi, 1809, *Contracaecum osculatum* Rudolphi, 1802,

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Table 1. Sampling details for the harbor porpoise, *Phocoena phocoena*, collected off Newfoundland and Labrador and examined for gastrointestinal helminths.

		Age group (yr)									
		Female					Male				
Location	Year	<1	1–3	4–6	≥7	Unknown	<1	1–3	4–6	≥7	Unknown
Southern Labrador	1991	—	—	—	—	1	—	—	—	—	—
Placentia Bay	1991	1	10	5	2	1	2	13	13	11	—
St. Mary's Bay	1987	—	—	—	—	1	—	—	—	—	1
	1990	1	—	1	1	—	—	1	—	1	1
	1991	—	1	2	—	—	—	—	1	—	—
Eastern Avalon	1990	—	—	2	—	—	1	—	—	—	—
	1991	—	1	—	—	—	—	—	1	—	—
Conception Bay	1990	—	1	—	—	—	—	—	—	—	—
	1991	—	2	—	—	—	—	1	1	1	—

and *Phocascaris* sp.), 3 cestodes (*Diphyllobothrium* sp. plerocercoids, *D. stemmacephalum* Cobbold, 1858, and *Tetrabothrius* sp.), 1 acanthocephalan (*Bolbosoma* sp.), and 1 digenean (*Campula oblongata* Cobbold, 1858) were found in the alimentary tracts examined (Table 2). The acanthocephalan and the cestode *D. stemmacephalum* were found only in the intestine, whereas the single species of digenean and the cestode *Tetrabothrius* sp. were found in the third stomach; nematodes were found throughout the alimentary tract (see later). Gastric ulcers, associated with the presence of larval and adult *A. simplex,* were observed in 1 porpoise; no other pathology was observed.

Ascaridoid nematodes, particularly *C. osculatum* (=*C. osculatum* B; for taxonomy, see Nascetti et al., 1993) were the most prevalent and abundant helminths in harbor porpoise stomachs and intestines (Table 2); other species were

Table 2. Helminth parasites of the alimentary tract of the harbor porpoise, *Phocoena phocoena*, from Newfoundland and Labrador.

Parasite	Prevalence	Abundance (±SE)	Maximum
A. Stomach (N = 80)			
Nematoda			
Anisakis simplex	47.5	3.18 ± 1.47	100
Contracaecum osculatum	83.8	25.31 ± 4.94	307
Phocascaris sp.*	30.0	0.89 ± 0.23	11
Cestoda			
Diphyllobothrium sp. (plerocercoids)	3.8	0.05 ± 0.05	2
Tetrabothrius sp.*	1.3	0.01 ± 0.01	1
Digenea			
Campula oblonga	7.5	0.15 ± 1.88	6
B. Intestines (N = 29)			
Nematoda			
A. simplex	13.8	0.17 ± 0.09	2
C. osculatum	75.9	14.76 ± 2.73	51
Phocascaris sp.	13.8	0.21 ± 0.10	2
Acanthocephala			
Bolbosoma sp.	6.9	0.07 ± 0.09	1
Cestoda			
D. stemmacephalum	6.9	0.07 ± 0.09	1

* Denotes new host record.

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Table 3. Numbers and developmental stages of ascaridoid nematodes recovered from various regions of the alimentary tract of the harbor porpoise, *Phocoena phocoena*, from Newfoundland and Labrador.

Nematode	Developmental stage†	Stomach compartment*			Intestinal section*									
		1	2	3	1	2	3	4	5	6	7	8	9	10
Anisakis simplex	L3	46	12	21	0	2	1	1	1	0	0	0	0	0
	L4	129	0	0	0	0	0	0	0	0	0	0	0	0
	Adult male	13	0	0	0	0	0	0	0	0	0	0	0	0
	Adult female (imm.)	24	0	0	0	0	0	0	0	0	0	0	0	0
	Adult female (mat.)	8	0	0	0	0	0	0	0	0	0	0	0	0
Contracaecum osculatum	L3	348	283	1,383	130	103	46	64	44	21	10	3	3	1
	L4	2	2	7	0	2	1	0	0	0	0	0	0	0
Phocascaris sp.	L3	35	12	24	1	0	1	0	4	0	0	0	0	0

* Each stomach (N = 80) consisted of 3 compartments, which were examined separately, 1 = keratinized forestomach, 2 = main stomach, 3 = pyloric stomach (after Smith, 1972). Intestines (N = 29) were divided into 10 sections of approximately equal length, numbered from anterior to posterior.

† Imm. and mat. = adult females without and with fully developed eggs in the uterus, respectively.

uncommon (prevalences <10%, abundances <1 per host). Mature specimens (i.e., with fully developed reproductive organs) were observed among only 3 of the 8 taxa found; these were *A. simplex* (3.0% of 267), *C. oblonga* (100% of 18), and *D. stemmacephalum* (both specimens with gravid proglottids). Both acanthocephalan specimens were immature females whose proboscides were not fully extended; the single specimen of *Tetrabothrius* sp. was approximately 6 cm long and immature.

The numbers of each developmental stage in various regions of the alimentary tract were determined for the 3 species of ascaridoid nematodes (Table 3). Adults and L4's of *A. simplex* were restricted to the keratinized forestomach (Table 3); L3's were also common in this region, but small numbers were found in other stomach compartments and also in intestinal sections 2–5. Specimens of *C. osculatum* were much more abundant and widely distributed throughout the alimentary tract, particularly in the third (pyloric) stomach and the anterior sections of the intestines. All *C. osculatum* recovered were larvae (L3's and L4's). *Phocascaris* sp., all L3's, were much rarer than other nematodes but were found in all stomach compartments and occasionally in the anterior sections of the intestine.

Calves (<1 yr old) were the only age group not infected with gastrointestinal helminths. Among the remaining age groups, there were no significant differences in prevalence ($P > 0.05$, multiway contingency analysis or Fishers exact test) or abundance ($P > 0.05$, Kruskal-Wallis and Wilcoxon tests) among host age groups and sexes for any of the species of helminths. Adults of *A. simplex* occurred in porpoises of a wide range of ages (2–9 yr) and in both males and females.

Examination of stomach contents indicated that most porpoises had recently fed; 93.4% of the stomachs contained recognizable food items. There was no evidence (from examination of the gullet during extraction of teeth) that food items had been regurgitated during capture. In terms of the percentage of stomachs containing a particular prey species, the dominant food item was capelin, *Mallotus villosus* (Muller) (88.5%), which also comprised the bulk of the stomach contents in most animals. Other dietary items included gadoids (19.2%), sand lance (*Ammodytes* sp., 16.7%), herring (*Clupea harengus harengus* L., 10.3%), and squid (Teuthoidea, 1.3%). Amphipods were also common (41.0%), whereas pandalid shrimps (2.6%) were rare.

Discussion

Adults of *A. simplex* are known from several species of marine mammals on the Pacific and Atlantic coasts of North America (see summaries by Margolis and Dailey, 1972; Margolis and Arai, 1989). Although adults of *A. simplex* have been observed in the stomach of a phocid, *Halichoerus grypus* Fabricius (McClelland, 1980; Brattey and Stenson, 1993), cetaceans are the principle definitive hosts. There have been few large-scale studies on the abundance of *A. simplex* in Cetacea from the Northwest Atlantic, and these data combined with those from numerous smaller-scale studies and anecdotal reports permit only tentative conclusions about the importance of

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the harbor porpoise relative to other Cetacea as definitive hosts of *A. simplex.*

Cowan (1967) reported variable numbers of *Anisakis* sp. in clusters of up to 100 worms in the stomach of 55 pilot whales, *Globicephala melaena* Traill, collected off Newfoundland, suggesting much higher abundances of *A. simplex* than those reported here. Scott and Fisher (1958a) found only 3 adults of *Anisakis* in the stomach of 150 harbor porpoises collected in the lower Bay of Fundy during May–November 1952–1956 but found 427 *Anisakis* in the stomach of a single beluga whale, *Delphinapterus leucas* Pallas. Vladykov (1944) reported that belugas from the Gulf of St. Lawrence were heavily infected with *Anisakis* spp., and Sergeant and Fisher (1957) observed nematodes, presumed to be *Anisakis,* in the stomach of each of 5 white-beaked dolphins, *Lagenorhynchus albirostris* Gray, from Conception Bay, Newfoundland. We observed 130 adults of *A. simplex* in the stomach of a *L. albirostris* from the same locality in March 1988 and several thousand adult *A. simplex* in the stomach of a humpback whale (*Megaptera novaeangliae* Borowski) caught in similar fashion in August 1992 in Lord's Cove, Burin Peninsula, Newfoundland (unpubl. obs.). Other records of *Anisakis* spp. in Cetacea are given in Margolis and Arai (1989).

There are undoubtedly some biases in the literature on parasites of Cetacea because animals with no worms are seldom reported; also, stranded animals are often the only source of samples, and their parasite faunas may not be representative. Nonetheless, our results generally agree with the extensive survey by Scott and Fisher (1958a) and suggests that the harbor porpoise in the inshore waters off Eastern Canada during the summer carry relatively few adults of *Anisakis.* The preceding summary suggests that cetaceans such as the *G. melaena, M. novaeangliae,* and *L. albirostris,* which are common around Newfoundland during summer (Sergeant and Fisher, 1957; Hay, 1982), carry on a per capita basis much heavier burdens of *A. simplex* and may therefore be more important in the transmission of the parasite to local fish stocks. The role of other common species, such as the minke (*Balaenoptera acutorostrata* Lacepede) and finback (*Balaenoptera physalus* (L.)), remains unknown because few specimens have been examined.

The presence of *A. simplex* in less than half of the harbor porpoises and the general rarity of adults of *A. simplex* in Northwest Atlantic harbor porpoises contrasts with the much heavier *Anisakis* burdens reported by J. W. Smith (1989) for *P. phocoena* from U.K. waters. However, differences in findings may partly be a seasonal effect because our samples were collected in summer (June–August) whereas Smith's samples were collected during winter (November–January). Surveys have shown that in the general area where our porpoises were collected 3 of the taxa we observed had in their stomachs larvae of *A. simplex* (e.g., capelin [prevalence 29%, abundance 0.37; Pálsson, 1986], adult herring [prevalence 33%, abundance 0.91; Parsons and Hodder, 1971], Atlantic cod, *Gadus morhua* L. (prevalence 37%, abundance 0.67; Brattey and Bishop, 1992]). These species of fish are therefore probably important dietary sources of larval *A. simplex* for harbor porpoise in our study area.

The most prevalent and abundant parasites were larvae of the ascaridoid nematode *Contracaecum osculatum.* The broad distribution of these larvae throughout the alimentary tract and the absence of adults suggest that they are unable to complete their development in this host and were being expelled. This species of nematode, along with *Phocascaris* sp., is common in the gastrointestinal tract of various phocids, particularly grey (*Halichoerus grypus*), harp (*Phoca groenlandica* Erxleben), and hooded (*Cystophora cristata* Erxleben) seals off Newfoundland and Labrador (Scott and Fisher, 1958b; Brattey and Ni, 1992; Brattey and Stenson, 1993). Harbor porpoises probably acquired the larvae of these nematodes by preying heavily on capelin. Data given by Pálsson (1986) indicate that larvae of *C. osculatum* (reported as *Contracaecum* sp.) were much more common (prevalence 63%, abundance 1.23) than larvae of *A. simplex* (prevalence 29%, abundance 0.37) in capelin from St. Mary's Bay, which broadly agrees with our findings on the relative abundance of these nematodes in harbor porpoise from the same general area.

Although water temperatures in the sampling area (at 40–90 m deep) are generally below 4°C during June–August (Colbourne and Fitzpatrick, 1994) and animals were kept cold and frozen as soon as possible after capture, postmortem migrations may have influenced the distribution of some of the parasites. In particular, *C. oblonga* and *Tetrabothrius* sp. possibly migrated as they normally occur in the bile ducts and anterior intestine, respectively, rather than the third stomach. Although adults of *A. simplex* were firmly anchored to the gastric mucosa, larvae were usually unattached, and the extent to which

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postmortem migrations influenced the distribution of larval nematodes remains unknown. However, the intestines of porpoises were more than 20 m long and, because chilling dramatically reduces the mobility of larval ascaridoids, it seems unlikely they would have migrated along a significant proportion of the intestines during the interval between capture and freezing.

This study provides the first record of the acanthocephalan *Bolbosoma* sp. from the harbor porpoise in the Atlantic, although Dailey and Stroud (1978) recorded *Bolbosoma* sp. from 1 of 4 *P. phocoena* from the Pacific coast of North America. Records of *Bolbosoma* spp. from other cetaceans are numerous, but individual hosts usually carry few specimens that are often recovered from hosts in poor condition, making the identification of species difficult (see Measures, 1992; Hoberg et al., 1993). Measures (1992) summarized records of *Bolbosoma* from North America and described *B. turbinella* (Deising, 1851) from blue whales, *Balaenoptera musculus* (L.) from the Gulf of St. Lawrence. *Bolbosoma capitatum* (Linstow, 1880) Porta, 1808, has been found in pilot whales, *G. melaena* (Cowan, 1967), and sperm whales, *Physeter macrocephalus* L. (Hoberg et al., 1993), in Canadian Atlantic waters. *Bolbosoma* sp. has also been found in Atlantic white-sided dolphins, *Lagenorynchus acutus* Gray (Beverley-Burton, 1978), off Maine. Balbuena and Raga (1993) found that *B. capitatum* was common (prevalence 46.5%, abundance 6.3) in the intestine of long-finned pilot whales, *Globicephala melas* Traill, at the Faroe Islands in the Northeast Atlantic. However, the general rarity of *Bolbosoma* in the harbor porpoise and other marine mammals in Canadian waters suggests that this parasite is generally rare in the Northwest Atlantic. The absence of mature specimens further suggests that the harbor porpoise is an atypical host.

Our findings together with those of Scott and Fisher (1958a) and Baker and Martin (1992) suggests that the helminth community in the alimentary tract of harbor porpoises is species-poor and is therefore consistent with that of other toothed whales (Cowan, 1967; Wazura et al., 1986; Balbuena and Raga, 1993; Aznar et al., 1994). Other notable characteristics of the helminth fauna are that none of the species recovered are specific to the harbor porpoise; a few occur in several species of cetacean (e.g., *A. simplex, C. oblonga*), but most appear to be either rare species (e.g., *D. stemmacephalum*) or "accidental infections" (e.g., *C. osculatum* and *Phocascaris, Bolbosoma, Diphyllobothrium* plerocercoids, and possibly *Tetrabothrius*). Samples from a broader range of localities and seasons that include collection of organs other than the alimentary tract are required to further characterize the helminth parasite fauna of the harbor porpoise. More detailed parasitological information could also help elucidate the stock structure of the Northwest Atlantic harbor porpoise, which at the moment is largely a matter of conjecture (see Gaskin 1984, 1992).

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Literature Cited

Aznar, F. J., J. A. Balbuena, and J. A. Raga. 1994. Helminth communities of *Pontoporia blainvillei* (Cetacea: Pontoporiidae) in Argentinian waters. Canadian Journal of Zoology 72:702–706.

Baker, J. R., and A. R. Martin. 1992. Causes of mortality and parasites and incidental lesions in harbour porpoises (*Phocoena phocoena*) from British waters. Veterinary Record 130:554–558.

Balbuena, J. A., and J. A. Raga. 1993. Intestinal helminth communities of the long-finned pilot whale (*Globicephala melas*) off the Faroe Islands. Parasitology 106:327–333.

Beverley-Burton, M. 1978. Helminths of the alimentary tract from a stranded herd of the Atlantic white-sided dolphin, *Lagenorhynchus acutus*. Journal of the Fisheries Research Board of Canada 35:1356–1359.

Brattey, J., and C. A. Bishop. 1992. Larval *Anisakis simplex* (Nematoda: Ascaridoidea) infection in the musculature of Atlantic cod, *Gadus morhua*, from Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences 49:2635–2647.

———, **and I.-H. Ni.** 1992. Ascaridoid nematodes from the stomach of harp seals, *Phoca groenlandica*, from Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences 49: 956–966.

———, **and G. B. Stenson.** 1993. Host specificity and abundance of parasitic nematodes (Ascaridoidea) from the stomachs of five phocid species from Newfoundland and Labrador. Canadian Journal of Zoology 71:2156–2166.

Colbourne, E., and C. Fitzpatrick. 1994. Temperature, salinity and density at station 27 from 1978 to 1993. Canadian Technical Report of Fisheries and Oceans 159:1–117.

Cowan, D. F. 1967. Helminth parasites of the pilot whale *Globicephala melaena* (Traill 1809). Journal of Parasitology 53:166–167.

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Dailey, M., and R. Stroud. 1978. Parasites and associated pathology observed in cetaceans stranded along the Oregon Coast. Journal of Wildlife Diseases 14:503–511.

Davey, J. T. 1971. A revision of the genus *Anisakis* Dujardin, 1845 (Nematoda: Ascaridata). Journal of Helminthology 45:51–72.

Gaskin, D. E. 1984. The harbour porpoise *Phocoena phocoena* (L.): regional populations, status and information on direct and indirect catches. Reports of the International Whaling Commission 34:569–586.

———. 1992. Status of the harbour porpoise, *Phocoena phocoena,* in Canada. Canadian Field Naturalist 106:36–54.

Hay, K. 1982. Aerial line-transect estimates of abundance of humpback, fin, and long-finned pilot whales in the Newfoundland–Labrador area. Report of the International Whaling Commission 32: 475–486.

Hoberg, E. P., P. Daoust, and S. McBurney. 1993. *Bolbosoma capitatum* and *Bolbosoma* sp. (Acanthocephala) from sperm whales (*Physeter macrocephalus*) stranded on Prince Edward Island, Canada. Journal of the Helminthological Society of Washington 60:205–210.

Margolis, L., and H. P. Arai. 1989. Parasites of marine mammals. *In* M. J. Kennedy, ed. Synopsis of the Parasites of Vertebrates of Canada. Alberta Agriculture Publication, Edmonton. 26 pp.

———, **and M. D. Dailey.** 1972. Revised annotated list of parasites from sea mammals caught off the West Coast of North America. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Report NMFS SSRF-647:1–23.

———, **G. W. Esch, J. C. Holmes, A. M. Kuris, and G. A. Schad.** 1982. The use of ecological terms in parasitology (report of an *ad hoc* committee of the American Society of Parasitologists). Journal of Parasitologists 68:131–133.

McClelland, G. 1980. *Phocanema decipiens*: pathology in seals. Experimental Parasitology 49:405–419.

———, **R. K. Misra, and D. J. Martell.** 1985. Variations in abundance of larval anisakines, sealworm (*Pseudoterranova decipiens*) and related species, in eastern Canadian cod and flatfish. Canadian Technical Report of Fisheries and Aquatic Sciences 1392:xi + 57 pp.

———, ———, **and** ———. 1990. Larval anisakine nematodes in various fish species from Sable Island Bank and vicinity. *In* W. D. Bowen, ed. Population Biology of Sealworm (*Pseudoterranova decipiens*) in Relation to Its Intermediate and Seal Hosts. Canadian Bulletin of Fisheries and Aquatic Science 222:83–118.

McGladdery, S. E. 1986. *Anisakis simplex* (Nematoda: Anisakidae) infection of the musculature and body cavity of Atlantic herring (*Clupea harengus harengus*). Canadian Journal of Fisheries and Aquatic Science 43:1312–1317.

McKerrow, J. H., J. Sakanari, and T. L. Deardorff. 1988. Anisakiasis: revenge of the sushi parasite. The New England Journal of Medicine 319:1228–1229.

Measures, L. N. 1992. *Bolbosoma turbinella* (Acanthocephala) in a blue whale, *Balaenoptera musculus,* stranded in the St. Lawrence Estuary, Quebec. Journal of the Helminthological Society of Washington 59:206–211.

Nascetti, G., R. Cianchi, S. Mattiucci, S. D'Amelio, P. Orecchia, L. Paggi, J. Brattey, B. Berland, J. W. Smith, and L. Bullini. 1993. Three sibling species within *Contracaecum osculatum* (Nematoda, Ascaridida, Ascaridoidea) from the Atlantic Arctic-Boreal Region: reproductive isolation and host preferences. International Journal for Parasitology 23:105–120

———, **L. Paggi, P. Orecchia, J. W. Smith, S. Mattiuci, and L. Bullini.** 1986. Electrophoretic studies on the *Anisakis simplex* complex (Ascaridida: Anisakidae) from the Mediterranean and Northeast Atlantic. International Journal for Parasitology 16:633–640.

Oshima, T. 1987. Anisakiasis—is the sushi bar guilty? Parasitology Today 3:44–48.

Pálsson, J. 1986. Quantitative studies on the helminth fauna of capelin (*Mallotus villosus* [Müller]) in the Northwest Atlantic for the purpose of stock discrimination. Canadian Technical Report of Fisheries and Aquatic Sciences 1499:v + 21 pp.

Parsons, L. S., and V. M. Hodder. 1971. Variation in the incidence of larval nematodes in herring from Canadian Atlantic waters. International Commission for Northwest Atlantic Fisheries Research Bulletin 8:5–14.

Richardson, S. F. 1992. Growth and reproduction in the harbor porpoise, *Phocoena phocoena* (L.), from eastern Newfoundland. M.Sc. Thesis, Department of Psychology, Memorial University of Newfoundland, St. John's. 102 pp.

Scott, D. M., and H. D. Fisher. 1958a. Incidence of a parasitic ascarid, *Porrocaecum decipiens,* in the common porpoise, *Phocoena phocoena,* from the lower Bay of Fundy. Journal of the Fisheries Research Board of Canada 15:1–4.

———, **and** ———. 1958b. Incidence of the ascarid *Porrocaecum decipiens* in the stomachs of three species of seals along the southern Canadian Atlantic mainland. Journal of the Fisheries Research Board of Canada 15:495–516.

Sergeant, D. E., and H. D. Fisher. 1957. The smaller Cetacea of eastern Canadian waters. Journal of the Fisheries Research Board of Canada 14:83–115.

Smith, F. R., and W. Threlfall. 1973. Helminths of some mammals from Newfoundland. The American Midland Naturalist 90:215–218.

Smith, G. J. D. 1972. The stomach of the harbor porpoise *Phocoena phocoena* (L.). Canadian Journal of Zoology 66:1611–1616.

Smith, J. W. 1989. Ulcers associated with larval *Anisakis simplex* B (Nematoda: Ascaridoidea) in the forestomach of harbour porpoises *Phocoena phocoena* (L.). Canadian Journal of Zoology 67:2270–2276.

———, **and R. Wootten.** 1978. *Anisakis* and Anisakiasis. Advances in Parasitology 16:93–163.

Thiel, P. H. van. 1966. The final hosts of the herringworm *Anisakis marina.* Tropical and Geographic Medicine 18:310–318.

Vik, R. 1963. Penetration of stomach wall by *Ani-*

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sakis-type larvae in porpoises. Canadian Journal of Zoology 42:513.

Vladykov, V.-D. 1944. Etudes sur les mammifères aquatiques. III. Chasse, biologie et valeur économique du Marsouin Blanc ou Béluga (*Delphinapterus leucas*) du fleuve et du golfe Saint-Laurent. Département des Pêcheries, Province de Québec. 193 pp.

Wazura, K. W., J. T. Strong, C. L. Glenn, and A. O. Bush. 1986. Helminths of the beluga whale (*Delphinapterus leucas*) from the Mackenzie River Delta, Northwest Territories. Journal of Wildlife Diseases 22:440–442.

Young, P. C. 1972. The relationship between the presence of larval anisakine nematodes in cod and marine mammals in British home waters. Journal of Applied Ecology 9:459–485.

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